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14. ABSTRACT
Background: The goal of this study was to examine neighborhood characteristics in relation to prostate cancer severity.
Methods: We studied African-American and Caucasian prostate cancer cases from the Pennsylvania State Cancer Registry. Census tract-level variables and deprivation scores were examined in relation to diagnosis age, stage, grade, and tumor aggressiveness. Multilevel analyses were conducted on a subset of patients from a longitudinal hospital-based study to examine the effects of neighborhood variables taking account of patient-level variables.
Results: We observed associations of socioeconomic status (SES) with high Gleason score among African-Americans residing in neighborhoods with low educational attainment (OR=1.34, 95% CI=1.13-1.60), high poverty (OR=1.39, 95% CI=1.15- 1.67), low car ownership (OR=1.46, 95% CI=1.20-1.78), and higher percentage of residents on public assistance (OR=1.32, 95%=1.08- 1.62). The highest quartile of neighborhood deprivation was also associated with high Gleason score. For both Caucasians and African-Americans, the highest quartile of neighborhood deprivation was associated with high Gleason score at diagnosis (OR=1.34, 95% CI=1.19-1.52; OR=1.71, 95% CI=1.21- 2.40, respectively.) Older age (65+ years) at diagnosis was also associated with low SES in African-Americans in Caucasians. In multilevel analyses, patient-level risk factors were significantly associated with most outcomes under investigation. However, in the African-American sample, we did observe associations of advanced tumor grade with neighborhood crime and advanced tumor stage with percentage of female-headed households and residents on public assistance in the neighborhood.
Conclusion: Using a neighborhood deprivation index, we observed associations between high grade prostate cancer and neighborhood deprivation in Caucasians and African-Americans. Future studies may consider the specific aspects of neighborhood SES, sociodemographics and crime that may affect advanced prostate cancer diagnosis and disparities in prognosis.

15. SUBJECT TERMS
Neighborhood characteristics, Socioeconomic Status (SES), Prostate Cancer, Deprivation

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Introduction

Neighborhood characteristics such as low socioeconomic status (SES) and aspects of social disorder or neighborhood stress are risk factors for a number of disease outcomes. It has been suggested that prostate cancer outcomes are also influenced by neighborhood characteristics and that these factors may contribute to prostate cancer disparities. The proposed multi-level study will combine neighborhood variables with patient-level risk factors, behaviors, medical history and family history to determine neighborhood influence on prostate cancer severity. This research will employ the infrastructure at the University of Pennsylvania Health System (UPHS) in Philadelphia and the Pennsylvania Cancer Registry to address the following specific aims:

Specific Aim 1. **To determine if neighborhood characteristics are associated with prostate cancer stage, grade and age at diagnosis in the Philadelphia 5-county region**

Specific Aim 2. **To evaluate multilevel interactions of neighborhood characteristics with patient-level risk factors in relationship to prostate cancer stage, grade and age at diagnosis**

Body

Statement of Work Years 1-2

Task 1: To determine if neighborhood characteristics are associated with prostate cancer stage, grade and age at diagnosis in the Philadelphia 5-county region

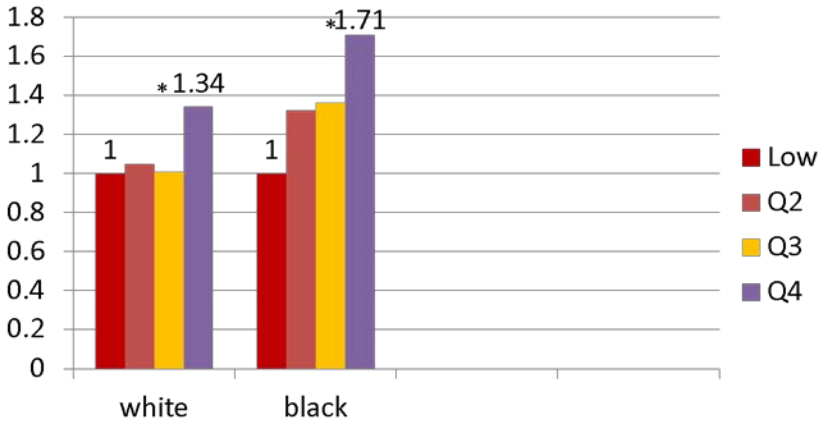
Examine associations between prostate cancer and outcomes using PA Cancer Registry data

- Purchase ArcGIS Desktop Program
  - ***Item has been purchased.***
- Completion of geocoding for the other 4 counties in the state dataset for the PA Cancer Registry
- ***Geocoding of the Cancer Registry data is completed.***
- UPENN Cartographic Modeling Laboratory gathering and formatting of Philadelphia county dat***a***
  - ***The Cartographic Modeling Laboratory (CML) maintains these data for Philadelphia County only. We have received crime data for Philadelphia County and have completed the analysis of those data.***
- Downloading census variables of interest
  - ***Downloading of SES variables is completed. We have also downloaded additional variables to capture neighborhood physical characteristics, and race, gender and age composition. A subset of these variables were used to calculate a neighborhood deprivation index using methods similar to Messer, et al. (2006.)(1) Using this validated index allowed us to examine the benefit of composite measures of neighborhood socioeconomic status compared to univariate measures.***
- Formatting variables and merging datasets
  - ***The primary datasets including geocodes and PA registry patient data were merged. We have merged and analyzed SES and demographic variables from the Census Bureau Website. All analyses with the PA Cancer Registry and the SCORE dataset are completed at this time.***
- Generate frequency tables and check for correlation of variables
  - ***Correlations and frequency tables for neighborhood SES variables have been computed for the PA Cancer Registry. Seventy-six percent of cases had a low-grade tumor and 86% had a low stage at diagnosis. The mean age at diagnosis was 67.9 years (median=68 years.) Significant correlations were observed among all Census Bureau derived neighborhood variables ($p<0.05$) except for inconsistencies for two. Percent of second language speakers was not correlated with family income, per capita income, male income, or percent unemployed. Percent of young high school drop-outs was not correlated with percent of working parents with children under age 6 years. Correlations were not observed among neighborhood crime variables except for number of thefts and total number of crimes ($r=0.887$), reported vandalism and total number of crimes ($r=0.765$), and number of aggressive assaults and number of aggressive assaults with a gun ($r=0.934$).***
- Build Regression models to analyze neighborhood associations
  - ***Regression models with the PA Cancer Registry dataset have been completed.***

- Summarize findings / prepare manuscripts
  - **Consultations with Dr. Andrew Rundle and Ms. Ann Tierney (biostatistician) resulted in a publication in a special Prostate Cancer Disparities edition of <u>Prostate Cancer</u>. The paper focused on neighborhood specific neighborhood variables and the use of quartiles of neighborhood deprivation to examine this composite variable in relation to prostate cancer severity. (2) This article can be found in Appendix 2.**
  - **<u>Neighborhood Crime –</u> Table 1 presents crime characteristics for Philadelphia County. There are significant differences in the number and type of crimes that occur in the neighborhoods of African-American vs. Caucasian prostate cancer patients. While the overall number of crimes in 2000 was greater for Caucasians, the incidence of aggressive crimes was greater for African-Americans. (p<0.001) The number of crimes increased significantly with increasing neighborhood deprivation. (p<0.001, Table 2)**
  - **<u>Neighborhood Deprivation</u> — A key finding from this study was that for both Caucasians and African-Americans, the highest quartile of neighborhood deprivation was associated with high Gleason score at diagnosis (OR=1.34, 95% CI=1.19-1.52; OR=1.71, 95% CI=1.21-2.40, respectively.)**

Associations (OR) of Increasing Neighborhood Deprivation and High Grade at Prostate Cancer Diagnosis

(PA Cancer Registry Southeastern 5-County Region, 1995-2005)



***Significantly different from low deprivation group (p<0.01)**

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<u>Statement of Work Years 2-3</u>

Task 2: To evaluate multi-level interactions of neighborhood characteristics with patient-level risk factors in relationship to prostate cancer stage, grade and age at diagnosis

Analyze multi-level interactions with screening history, risk behaviors, obesity, and medical history in the SCORE Study

- Continue accrual of all patient cases for the SCORE Study
    - **Patient accrual continues through the parent study at Presbyterian Hospital, an affiliate of the Hospital of the University of Pennsylvania. However, we have completed the accrual for the current study as we at the end of the final funding period. We currently have 224 African-American cases and 1159 Caucasian cases from the Pennsylvania 5-county region geocoded. However, at the time of this report, our available sample size with complete data for these analyses may reflect a slightly smaller sample. Our smaller sample size than earlier reports also reflects the fact that under recent research regulations at the Philadelphia VA Hospital, we do not currently have permission to use identifiable patient information for the VA patients that were accrued at an earlier date. This new policy eliminated ~200 eligible African-American patients accrued for the parent study from participating in our study which required addresses for geocoding.**
- Continue medical record abstraction and data entry
    - **Medical record abstraction is ongoing under the parent study but has been completed for the purposes of the current report.**
- Geocoding of remaining 5-county SCORE sample
    - **Geocoding has been added to the protocol of the parent study and now has been completed for the purposes of the current report.**
- Merge final datasets and format patient-level variables
    - **The merger of datasets has been completed.**
- Confirmation of Aim 1 findings using the SCORE Study
    - **Correlations and frequency tables for the SCORE dataset have been completed. We focused these analyses on the variables that were found to be most important in the larger PA Cancer Registry dataset. The correlations were similar to what we observed in the state registry, showing highly correlated neighborhood variables. As expected, our subset of hospital-based urology patients differed from the larger state sample of prostate cancer patients with regard to tumor characteristics. 47% of cases in SCORE had low grade tumors while 74% were low stage at diagnosis. These are lower percentages than were reported in the larger state registry. (2) The mean age at diagnosis was 61.8 (median=62 years), so they were diagnosed about 6 years earlier than the average for other men from our area in the state registry.**
- Determine race interactions in each univariate model.
    - **Models to analyze race interactions have been constructed for each of the primary predictor variables in separate analyses. These models also adjusted for age and year of diagnosis to be consistent with other analyses conducted with state registry and SCORE data. We observed race interactions for the following neighborhood variables in relation to**
        - **Older age (65+) at prostate cancer diagnosis: High % female head of household (interaction p=0.033); High % of residents on public assistance (interaction p=0.038); Third quartile deprivation (vs. first or lowest, interaction=0.026).**

        - **High Tumor Grade (7+): High % of residents on public assistance (interaction p=0.048).**
- Stratify by race and build regression models to analyze multilevel affects of neighborhood and patient-level variables in relation to prostate cancer outcomes
    - **Multilevel regression models have been completed. Results are summarized below.**
- Summarize findings / prepare manuscripts
    - ***Multilevel Model Construction with the SCORE dataset — Because of collinearity, the analytic models for each outcome of interest (age, stage, grade, and tumor aggression at diagnosis) included neighborhood variables separately except for the three crime variables that were included. The crime variables (gun assaults, graffiti and vandalism/criminal mischief) were not strongly correlated with one another (all r<0.48) and were therefore included in the same multilevel models.***

      Patient-level variables considered for these initial models were race, obesity (BMI), age, family history of prostate cancer, smoking history, diagnosis year, marital status, benign prostatic hyperplasia (BPH), dietary factors (red meat, dairy, fruits and vegetables, soy, fish, tomatoes, beer, wine, liquor, multivitamins), education, and prostate specific antigen level (PSA) at diagnosis. These variables were analyzed univariately for associations with one or more of the outcomes of interest. Those with any significant associations (race, obesity, age, family history, diagnosis year, marital status, multivitamin intake, education, and PSA) were maintained for inclusion in initial Generalized Estimating Equations (GEE) models which controlled for clustering by census tract. (3)

      After initial testing, we observed several cases of convergence failures in the regression models. With the help of our new research team biostatistician, Dr. Knashawn Morales, we determined that the limited sample size of the SCORE sample was further limited by missing data for two variables in particular for which data collection commenced later in the parent study. With the removal of obesity and multivitamin intake, we were able to achieve convergence for the majority of models. For the few where convergence was still an issue, logistic was used instead. In those cases, there was not enough variability within census tracts to warrant the use of GEE models.

    - ***Neighborhood Characteristics and SCORE Analyses –*** **Differing from the state registry data (2), we found no racial differences in age or tumor characteristics in SCORE. However, African-Americans were less likely to be married (p<0.001). Consistent with the state cancer registry, there were significant racial differences in all of the neighborhood characteristics examined (p<0.001). (Table 3)**

      Table 4 shows race stratified analyses of neighborhood characteristics for each of the outcomes of interest. With the SCORE subset, we were not able to observe significant associations

in census tract SES variables with tumor characteristics that we published recently on the PA registry data. (2), there were significant associations observed for tumor aggressiveness with higher neighborhood vandalism (African-American OR=2.40, 95% CI= 1.03-5.58) and for high Gleason grade and neighborhood graffiti (African-American OR=2.39, 95% CI= 1.17-4.90). There were also protective effects of specific neighborhood characteristics with advanced age at diagnosis. These variables included low neighborhood education (Caucasian OR=0.62, 95% CI=0.46-0.86) and high percentage of residents on public assistance (Caucasian OR=0.49, 95% CI=0.49-0.93). In our most recent analyses with the PA Cancer Registry, we have found associations of most neighborhood characteristics with advanced age at diagnosis (although in the opposite direction, perhaps the result of the older median age in this sample) and a similar associations of higher stage, grade, and tumor aggression with gun assaults in Caucasians only (Table 5.)

- **SCORE Prostate Cancer Multilevel Analyses Results -- Table 6 presents the multilevel results with estimates for patient-level and neighborhood-level variables in the SCORE sample.**
  - **In Caucasians, the variables associated with older age at diagnosis were marital status (increased odds) and later year of diagnosis (protective.) For African-Americans, only later year of diagnosis was associated (protective) in all of the models.**
  - **In Caucasians, the variables associated with advanced stage were elevated PSA level and family history of prostate cancer (increased odds), except in the model including neighborhood crime. In that model, elevated PSA level and family history of prostate cancer (increased odds) were related to advanced stage. In African-Americans, the significant relationships were found for elevated PSA level (increased odds) and being married, high neighborhood percentage of female head of household and high percentage of residents on public assistance (protective.)**
  - **For Caucasians, higher tumor grade is associated with elevated PSA (increased odds), post graduate education (in the model containing % neighborhood public assistance) and gun assaults (protective.) Tumor grade in African-Americans was associated with more recent diagnosis, elevated PSA (in the neighborhood crime model), graffiti, (increased odds), and vandalism (protective.)**
  - **In both racial groups, elevated PSA was associated with aggressive disease with family history also demonstrating significance in the model with neighborhood crime for the Caucasian sample (increased odds.)**

- ***SES Discordance and Obesity in Prostate Cancer:*** **In new preliminary analyses, we have observed that obese prostate cancer cases are younger at diagnosis, less educated and tend to be more likely to live to live in low income neighborhoods compared to non-obese patients. (Table 7) They were also more likely to live in SES discordant neighborhoods (those in which patient level education was below college but neighborhood income was below the sample median.) In this discordant situation, the association between obesity and high prostate cancer grade was increased (OR=2.78, 95% CI=1.17-6.64)**

Key Research Accomplishments

- **We learned that high grade prostate cancer is associated with neighborhood deprivation in Caucasians and African-Americans.**
- **We observed associations between neighborhood SES variables and crime variables with prostate cancer outcomes (stage and grade) in multilevel models that adjusted for patient-level variables in a diverse group of patients**
- **We observed that contextual effects from the residential neighborhood were often greater for African-Americans than for Caucasians. In particular, even in fully-adjusted, multilevel analysis, high neighborhood percentage of female head of household or residents on public assistance were found to be inversely associated with advanced stage prostate cancer among African Americans. Reports of graffiti in the neighborhood increased the odds for advanced tumor grade in African-Americans while reports of vandalism were protective in this group.**
- **For Caucasians, higher tumor grade was less common among men residing in neighborhoods with a higher percentage of gun assaults.**
- **Maps showed us where high risk patients are concentrated in our region so that those geographic areas can be targeted for future research endeavors.**

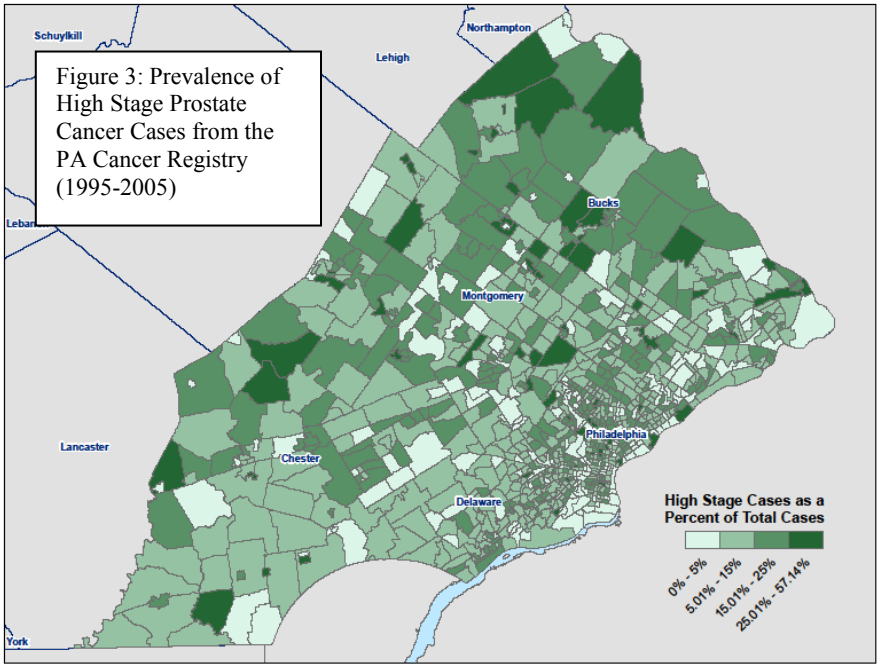

Figure 3: Prevalence of High Stage Prostate Cancer Cases from the PA Cancer Registry (1995-2005)

Reportable Outcomes (September 2011- August 2012)

- **Obtained funding as PI of a research project on a P-60 Grant: Comprehensive Center of Excellence in Health Disparities (2012-2017, NIH)**
  Project: "Building multilevel models to examine the relationship between obesity and prostate cancer disparities in outcomes"

- **Disparities Research Training for PI**
  - **2012 Summer Nursing Research Institute Fellow (Designing Health Promoting Interventions to Reduce Health Disparities), University of Pennsylvania**

- **Bibliography of publications and abstracts**

  Publication
  - **Zeigler-Johnson C, Tierney A, Rebbeck T, Rundle A: Prostate cancer severity associations with neighborhood deprivation. Prostate Cancer doi:10.1155/2011/846263, 2011.**

  Abstracts
  - ***Zeigler-Johnson C, Liu Z, Spangler E, Rebbeck T.: Effects of Obesity and Neighborhood Socioeconomic Status on Prostate Cancer Outcomes. Resource Centers for Minority Aging Research (RCMAR) 2010 Annual Investigators Meeting, Philadelphia, PA May 2010 Notes: Poster Presentation.***
  - ***Zeigler-Johnson C, Liu Z, Spangler E, Rebbeck T.: Effects of Obesity and Neighborhood Socioeconomic Status on Prostate Cancer Stage and Grade. AACR Science of Health Disparities Meeting, Miami, FL September 2010 Notes: Poster Presentation.***
  - ***Zeigler-Johnson C, Spangler E, Rebbeck T.: Neighborhood Characteristics and Prostate Cancer Severity. Innovative Minds in Prostate Cancer Today Conference March 2011 Notes: Poster Presentation.***

List of Personnel Receiving Pay from Research Effort

- **Charnita Zeigler-Johnson, PI (salary support)**
- **Timothy R. Rebbeck, collaborator (salary support)**
- **Elaine Spangler, project manager (salary support)**
- **Andrew Rundle, consultant (consultant fees)**
- **Cartographic Modeling Laboratory Staff (hourly fees for specific tasks)**

Conclusion

Prostate cancer is the most prevalent non-cutaneous malignant cancer in the U.S. The disease occurs at a high incidence, differentially affecting African-American men who are at highest risk and suffer the greatest mortality associated with prostate cancer (4). In spite of its common occurrence and the strong racial disparities that exist in prostate cancer, modifiable risk factors have not been confirmed. These disparities are believed to be a result of interactions among genes, health behaviors, and environmental factors.

Neighborhood SES, such as indicated by neighborhood income or poverty level, has been used in several studies assessing residence and clinical outcome. (5-9). Higher SES communities appear to have fewer hazards, more support, and more options for coping when problems do arise. Limited income, education, and/or low social class may increase the likelihood that people live in poorer, stressful settings(10). Neighborhood characteristics such as degree of deterioration, urbanization, poverty, educational attainment and percentage of low-income residents have been correlated with increasing disease rates and poorer health outcomes, including mortality (7, 11-14). To date, few studies have examined prostate cancer severity by neighborhood SES (15-17) or deprivation. (18, 19) No other published studies have examined neighborhood crime associations or used a multi-level approach including neighborhood factors plus patient-level behaviors, medical and family history, obesity and demographics.

The results of this project to date demonstrate that there are significant associations of neighborhood SES and crime on prostate cancer severity that are independent of patient age, race and other patient-level factors. Southeastern Pennsylvania patients residing in low income neighborhoods were more likely to be diagnosed with prostate cancer at an older age. African Americans and Caucasians living in high deprivation neighborhoods were significantly more likely to be diagnosed with high grade prostate cancer. The association was strongest among African-American cases. Most of these neighborhood variables measure similar SES parameters, so observed associations are expected for multiple variables and in the same direction. Although African-Americans are at high risk for advanced prostate cancer, it is interesting that this particular outcome and not stage is so consistently associated with low neighborhood SES only in African-Americans. This is the first report that the authors are aware of showing this difference by race and suggests that tumor grade in African-Americans may be particularly prone to neighborhood influences. The Gleason score may be less affected by screening practices than stage at diagnosis, and therefore may be more closely tied to biological mechanisms of prostate cancer progression. Although speculative, these mechanisms may be genetic or tied to other risk factors that are disproportionately prevalent among African-Americans. Obesity is one factor that is more common in African-Americans and is associated with a biologically more aggressive form of prostate cancer. (20) Obesity varies by SES factors and, therefore, may be even more relevant in the discussion of prostate cancer disparities. As African-Americans are much more likely than Caucasians to live in disadvantaged areas (21), the possibility of an interaction among patient-level and neighborhood-level SES is possible. These results also suggest that neighborhood dynamics may influence prostate-cancer screening and treatment seeking-behavior differentially by neighborhood SES and race.

We also observed independent effects of crime variables (gun assaults, graffiti and vandalism/criminal mischief) in prostate cancer severity. It has been shown that among similar low income communities in the same city, those that are well-maintained (clean, no graffiti/vandalism, no car abandonment) have lower disease rates than those

that are less maintained. (22) Our associations suggest the possible activation of stress pathways and interaction with the contextual environment in the progression of prostate cancer.

Significance ("So what?")

Prostate cancer has the highest incidence of any cancer site in American men. African Americans suffer from the highest rates of prostate cancer in the world, presenting with more advanced disease at initial diagnosis and have a worse prognosis than European American men. Studies to date have not determined the reasons for the high rates and apparent ethnic disparities, but it is likely that these disparities are multifactorial and complex.

One issue related to prostate cancer that is not well studied is that of the environmental contribution to disease progression. Individual patient characteristics do not fully explain the occurrence of advanced disease among prostate cancer cases, and only a subset of patients is at risk for advanced disease. Studying environmental factors may help to elucidate prostate cancer causes of progression and provide additional information about the groups of men that are at highest risk for advanced disease.

Residential neighborhoods are promising venues for identifying environmental pathways to disease and for studying contextual variables and environmental interactions with other risk factors. Neighborhoods in the US vary widely by a number of key factors that may influence one's well-being, stress level, lifestyle, and ultimately, disease susceptibility. These factors also differ substantially by race.

Although it long remained unclear which neighborhood factors were most important in determining certain disease outcomes, our work is helping to identify many neighborhood affects on prostate cancer, which include SES and lifestyle factors. The mechanisms of the pathways that lead to cancer pathogenesis overlap and interact, reflecting the complexity of cancer progression and making it difficult to determine the causal pathways. If multiple and seemingly different health outcomes occur together across communities and are predicted by similar neighborhood characteristics, there may be underlying causes/mediating mechanisms that cause these health effects at the neighborhood level. (23) Although neighborhood factors overlap quite a bit, the primary categories for ecologic influences on health include neighborhood SES, racial composition, psychosocial factors, and physical components. Multilevel analysis of neighborhood characteristics with prostate cancer outcomes may provide insight into new factors and pathways to pursue in the quest to unravel the mysteries of prostate cancer progression and disparities. Modification of other putative risk factors may also be found by stratifying analyses by neighborhood characteristics, thereby examining associations in context. The results of this project hopefully will suggest how high risk communities for poor outcomes (or individuals from those communities) might be targeted with more intense cancer education, early detection and prevention tactics.

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Appendices

Appendix 1 – Abstracts

EFFECTS OF OBESITY AND NEIGHBORHOOD SOCIOECONOMIC STATUS ON PROSTATE CANCER STAGE AND GRADE

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Background: Prostate cancer is a common, complex disease with few confirmed risk factors, including advancing age. African-Americans are at highest risk for developing prostate cancer and often present with advanced disease. Obesity has been shown to increase the risk of advanced disease and poor outcomes. Although linked to obesity and advanced cancer, neighborhood socioeconomic status (SES) has not been studied as a modifier of obesity effects in prostate cancer patients.
Objective/Hypothesis: The goal of this project is to identify neighborhood factors that are associated with prostate cancer outcomes. Residing in disadvantaged neighborhoods has been linked to a number of disease outcomes and mortality. There are significant differences in the neighborhood conditions of many African-Americans compared to European-Americans. These differences may help to explain the racial differences observed in prostate cancer outcomes. Our general hypotheses are that neighborhood SES differs for African-American and European American prostate cancer patients, and that neighborhood SES modifies the effects of obesity on prostate cancer outcomes.
Specific Aims:

- **Specific Aim 1:** To determine the prevalence of neighborhood disadvantage in European American and African American prostate cancer patients.
- **Specific Aim 2:** To identify patient-level confounders that are associated with neighborhood disadvantage and obesity using prostate cancer cases from the Study for Clinical Outcomes, Risk and Ethnicity (SCORE)
- **Specific Aim 3:** To examine the modification of BMI effects on prostate cancer outcomes by neighborhood SES.

Methods: A case-case study design is proposed to examine the relationship between neighborhood characteristics and prostate cancer severity. The residential addresses of prostate cancer patients from the SCORE Study at the University of Pennsylvania will be geocoded. Census tract data will be downloaded from the Census Bureau website and merged with patient data. Outcomes for this study will include tumor stage, tumor grade, age at diagnosis and biochemical (treatment) failure. Multivariate models will be used to examine the effects of obesity on prostate cancer outcomes stratified by neighborhood SES. Analyses will be stratified by race to determine if the observed effects differ by ethnicity.
Results: Preliminary results from this work demonstrated associations of obesity with tumor characteristics and risk of treatment failure. Among 924 patients who underwent radical prostatectomy, obesity was associated with higher tumor stage. Obesity was also a risk factor for biochemical failure in African American men (HR 4.59, CI 95% =1.87-11.2), suggesting that obesity may in part explain poorer prostate cancer prognosis seen in African Americans. Analyses are in progress to evaluate modifying effects of neighborhood SES.
Conclusions: Obesity increases the risk for poor prognosis from prostate cancer. Future research will determine if neighborhood SES modifies these effects.

Multilevel Analysis of Neighborhood Characteristics and Prostate Cancer Severity

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Background/Objectives: African-Americans are at highest risk for developing prostate cancer and often present with advanced disease. Differences in the neighborhood conditions of African Americans and European Americans may help to explain the racial differences observed in prostate cancer outcomes, as residing in disadvantaged neighborhoods has been linked to a number of disease outcomes. The goal of this project is to identify the neighborhood-level factors that are most strongly associated with prostate cancer severity. The specific aim of this project is to determine if neighborhood characteristics are associated with prostate cancer stage, grade and age at diagnosis in African-American and European-American men in the Philadelphia, PA region.
Methods: Residential addresses of 5,684 African-American and 14,601 European-American prostate cancer patients from the PA registry (1995-2007) were geocoded and linked to census tract data. Multivariate models were conducted to determine which variables were associated with less than age 60 at diagnosis, higher stage (T3 and 4) and higher grade. Variable quartiles were evaluated in separate models to avoid collinearity. Age at diagnosis was included in models examining tumor stage and grade as outcomes.
Preliminary Results: Preliminary results of our analyses identified associations of prostate cancer severity with a number of neighborhood socioeconomic variables. Younger age at diagnosis was more common among residents in higher income neighborhoods ($p<0.001$) and those with a higher percent of residents in the workforce ($p<0.001$). Higher proportion of bilingual residents in the neighborhood was associated with increased odds of young diagnosis among African-Americans ($p<0.01$). Higher proportions of residents with less than high school education decreased the odds of early diagnosis for both ethnic groups ($p<0.05$). For European Americans, higher tumor grade was significantly less likely among high income neighborhoods ($p<0.01$) and neighborhoods with high percent of young adults with college degrees ($p<0.05$). Also for European-Americans, higher stage at diagnosis was inversely associated with higher percent of bilingual residents ($p<0.05$) and higher percent of young adults attending college ($p<0.001$).
Conclusions: The early results of this study demonstrated significant effects of neighborhood socioeconomic factors on prostate cancer severity. Significant factors varied by prostate cancer characteristic and ethnic group, suggesting that different contextual variables may determine prostate cancer severity among diverse populations. Future analyses will explore neighborhood stress, racial composition, and physical characteristics. Additional analyses with a subset of cases will add patient-level variables to multi-level models.
Impact: This study focuses on neighborhood factors that impact risk for advanced prostate cancer and may differentially impacts minority groups who are often more likely to live in disadvantaged areas. Significant neighborhood effects may identify groups of patients at highest risk for poor outcomes and provide strategies for effective intervention in high-risk communities.

COMMUNITY CONTEXT: LINKING NEIGHBORHOOD DATA AND PROSTATE CANCER SEVERITY

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Background: Prostate cancer is a common, complex disease with few confirmed risk factors, including advancing age. African-Americans are at highest risk for developing prostate cancer and often present with advanced disease. Obesity has been shown to increase the risk of advanced disease and poor outcomes. Although linked to both obesity and cancer severity, neighborhood factors, such as socioeconomic status (SES), have not been studied as a modifier of obesity effects in prostate cancer patients.

Objective/Hypothesis: The goal of this project is to identify neighborhood factors that are associated with prostate cancer severity. Differences in the neighborhood conditions of African Americans and European Americans may help to explain the racial differences observed in prostate cancer outcomes, as residing in disadvantaged neighborhoods has been linked to a number of disease outcomes and mortality. Our hypothesis is that neighborhood characteristics are related to prostate cancer severity and may modify the relationship between obesity and prostate cancer outcomes among men.

Specific Aims:

Specific Aim 1: To determine the prevalence of neighborhood disadvantage in European American and African American prostate cancer patients.

Specific Aim 2: To identify patient-level confounders that are associated with neighborhood disadvantage and obesity using prostate cancer cases from the Study for Clinical Outcomes, Risk and Ethnicity (SCORE)

Specific Aim 3: To examine the modification of BMI effects on prostate cancer outcomes by neighborhood characteristics.

Methods: A case-case study design is used to examine the relationship between neighborhood characteristics and prostate cancer severity among men in the Philadelphia, PA region. The residential addresses of prostate cancer patients from the SCORE Study at the University of Pennsylvania are geocoded. Census tract data are downloaded from the Census Bureau website and merged with patient data. Outcomes for this study include tumor stage, tumor grade, age at diagnosis and treatment failure. We will build multivariate models to examine the effects of obesity on prostate cancer outcomes stratified by neighborhood variables focusing on SES. Analyses are also stratified by race to determine if the observed effects differ by ethnicity.

Results: Preliminary results showed differences in neighborhood characteristics by race and identified associations with prostate cancer severity. Obesity was also associated with tumor characteristics. Among 924 patients who underwent radical prostatectomy, obesity was associated with higher tumor stage among men residing in low SES neighborhoods, regardless of ethnicity. Obesity increased the odds of high Gleason Score at diagnosis among European Americans, but in a less consistent manner than observed for tumor stage.

Conclusions: Obesity increases the risk for poor prognosis from prostate cancer, but this relationship is modified by neighborhood SES. Future research will determine other neighborhood factors that are important in prostate cancer outcomes and examine risk factor interactions with neighborhood context.

Appendix 2 -- Manuscript

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Research Article

Prostate Cancer Severity Associations with Neighborhood Deprivation

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Background. The goal of this paper was to examine neighborhood deprivation and prostate cancer severity. *Methods*. We studied African American and Caucasian prostate cancer cases from the Pennsylvania State Cancer Registry. Census tract-level variables and deprivation scores were examined in relation to diagnosis stage, grade, and tumor aggressiveness. *Results*. We observed associations of low SES with high Gleason score among African Americans residing in neighborhoods with low educational attainment (OR = 1.34, 95% CI = 1.13–1.60), high poverty (OR = 1.39, 95% CI = 1.15–1.67), low car ownership (OR = 1.46, 95% CI = 1.20–1.78), and higher percentage of residents on public assistance (OR = 1.32, 95% = 1.08–1.62). The highest quartile of neighborhood deprivation was also associated with high Gleason score. For both Caucasians and African Americans, the highest quartile of neighborhood deprivation was associated with high Gleason score at diagnosis (OR = 1.34, 95% CI = 1.19–1.52; OR = 1.71, 95% CI = 1.21–2.40, resp.). *Conclusion*. Using a neighborhood deprivation index, we observed associations between high-grade prostate cancer and neighborhood deprivation in Caucasians and African-Americans.

1. Introduction

Prostate cancer is the most prevalent malignant cancer among men in the U.S. 217,730 incident cases were expected in 2010 [1]. The advent of prostatic specific antigen (PSA) testing has driven large increases in diagnoses with dramatic increases observed between 1988 and 1993, coinciding with the advent of widespread PSA testing [2–4]. African Americans have a significantly higher risk of disease than Caucasian men, tend to be diagnosed with more aggressive disease, and suffer the greatest mortality associated with prostate cancer [5]. In spite of its common occurrence and strong racial disparities, modifiable risk factors for prostate cancer have not been confirmed. These disparities are believed to be a result of interactions among genes, health behaviors, and environmental factors.

Economic, physical, and social characteristics of residential neighborhoods may influence health-related behaviors, screening behaviors and health conditions. Disadvantaged neighborhoods are often correlated with higher levels of environmental pollutants, overcrowding, violence, less social cohesion, and less access to services [6]. Of particular importance for diseases such as prostate cancer in which screening practices have had large effects on incidence, low-income neighborhoods often have fewer medical facilities and these facilities are often stressed due to higher burdens of indigent care. The effects of race-based residential segregation may also have a distinct effect on the spatial accessibility of health care facilities [7]. A recent national study showed that in the most segregated counties, a greater proportion of African American residents was associated with a significantly lower volume of outpatient surgery, fewer ambulatory surgery facilities, fewer general surgeons, and a significantly higher volume of emergency medical visits [8].

Only a few studies have investigated the effects of neighborhood economic and social conditions on prostate cancer

incidence and aggressiveness at diagnosis. However the extant data suggest that higher socioeconomic status measured at the individual or neighborhood level predicts a higher risk of prostate cancer diagnosis and a lower risk of late-stage disease at diagnosis. The National Program of Cancer Registries Patterns of Care Study found that higher average neighborhood educational attainment and income measured at the Census Tract level is associated with lower-stage prostate cancer at diagnosis [9]. Recent analyses of SEER-Medicare data show that higher zip code level median household income is protective against advanced stage disease at diagnosis [10].

Although socioeconomic and ethnic differences in prostate cancer outcomes persist, no studies of neighborhood level factors have reported on prostate cancer severity as an outcome stratified by race. Additionally, prior studies have tended to focus on single variable indicators of socioeconomic status, for instance percent poverty, which do not necessarily reflect all of the dimensions of socioeconomic stratification across neighborhoods. The aims of this study were: (1) to determine if census tract level SES factors are differentially associated with indicators of prostate cancer severity by race and (2) to determine whether a more comprehensive measure of neighborhood SES more strongly predicted prostate cancer severity than single variable indicators of economic stratification.

2. Materials and Methods

2.1. Study Participants. Anonymized data from the Pennsylvania Department of Health was provided on prostate cancer patients diagnosed in the Commonwealth of Pennsylvania from 1995 to 2007. In the present analysis, we focused on a sample who resided in Southeastern Pennsylvania, the primary service area of patients at the University of Pennsylvania and representative of the Philadelphia metropolitan area. The geocoded subset of patients focused on Philadelphia county and the surrounding 4 counties (Bucks, Delaware, Montgomery, and Chester). This sample identifies a targeted region with a defined population base representing a variety of sociodemographic conditions of interest to the present analysis. Residential addresses of prostate cancer patients in the Pennsylvania cancer registry were cleaned by trained research staff and geocoded with Arc GIS. A total of 5,136 African American and 16,672 Caucasian men were geocoded from this Philadelphia 5-county region.

2.2. Neighborhood Variables. Census data describing the sociodemographic characteristics of the census tracts for the five counties were downloaded from the Census Bureau web site (http://www.census.gov) from 2000 Census Summary File 3. Downloaded data were census tract characteristics of interest for this study. Variables extracted from this database included household income, adult high school educational attainment, percent poverty, percent of female-headed households with dependent children, percent of households with no car, percent of households on public assistance, percent of unemployed adults, percent vacant housing units, percent of homes with more than 1 occupant per room, home value, percent of non-Hispanic Black residents, percent of males in management positions, percent of females in management positions, percent of males in professional occupations, percent of females in professional occupations, percent of rented units, percent of males not in the labor force, percent of total population 65 years and over, percent of residents who did not move since 1995, and percent of renters or owners paying more than 50% of income for home.

We also calculated a deprivation index based on one originally developed and tested by Messer et al. on several geographic regions in the U S [11]. The index uses a principal components analysis (PCA) approach. The deprivation index was used to facilitate the comparison of neighborhood deprivation and health across geographic areas. Twenty census variables described and selected by Messer et al. were included in our PCA [11]. They characterized SES and demographic domains associated with health outcomes in the literature. The variables that loaded in the top 20 percentile (explaining the greatest amount of variance) were retained for inclusion in the deprivation index. These 5 variables were (1) percent of households with income < \$30,000/year, (2) percent poverty, (3) percent of households on public assistance, (4) percent of female head of household with dependent children, and (5) percent of households with no car. A final PCA was run with the 5 retained variables to determine the weight of each variable's contribution to the deprivation score for each census tract in the study area. The weighted deprivation score standardized by SAS to have a mean of 0 and standard deviation of 1 ranged from −1.07 (low deprivation) to +4.02 (high deprivation). Quartiles of continuous neighborhood deprivation were then created.

2.3. Outcome Variables. Our primary outcome variables were indicators of prostate cancer severity that are associated with differences in long-term survival [12]. These variables include tumor stage, with low stage defined as stages 1 and 2 (localized disease), and high-stage is defined as stages 3 and 4 (nonlocalized); tumor grade, with low grade is defined as tumor Gleason score of 6 or below and high-grade is defined as a tumor score of 7 or greater; and tumor aggressiveness, defined as a combined high tumor stage (stage 3 or 4) and high tumor grade (grade 7+) compared to those with other combinations of these variables.

2.4. Statistical Analyses. t-tests were used to compare age means for the groups. χ^2 (frequency) tables were evaluated using Pearson chi-square tests to determine significant differences by race for categorical patient-level and neighborhood-level variables. Generalized estimating models (GEE) using a logit link function, binomial distributions, and robust standard error estimation were used to estimate odds ratios (OR) for associations between neighborhood socioeconomic measures and prostate outcomes accounting for the clustering of multiple patients within census tracts [13]. Two-sided P-values <0.05 were considered significant.

Stratifying the data by race (African American or Caucasian), frequency tables and GEE models were used to determine which neighborhood variables are associated with prostate cancer outcomes. Multicollinearity is an issue when modeling neighborhood variables, so we examined each neighborhood variable in separate models [14]. We also created GEE models to examine the quartiles of the deprivation index in relation to outcome variables. The first quartile, representing lowest neighborhood deprivation, was the reference group. Additional unstratified analyses (adjusting for African American race compared to Caucasian) were conducted to examine whether racial differences are attenuated when census tract-level variables are added to the models. We adjusted for age group <60 or ≥60 and year of diagnosis (modeled as a continuous variable) in all GEE models.

3. Results

3.1. Sample Characteristics. Table 1 presents demographic characteristics of prostate cancer patients by race. There were significant ethnic differences for all patient-level variables ($P < 0.001$). Compared to Caucasians, African Americans were younger (66 versus 68 years), less likely to be married (57% versus 77%), and more likely to have unfavorable prostate cancer characteristics (high-stage, 15% versus 12%, and high Gleason Score, 28% versus 22%).

3.2. Neighborhood SES Characteristics. Table 1 also presents SES characteristics of the patients' residential census tracts. There were significant ethnic differences for all neighborhood-level variables ($P < 0.001$). Compared to Caucasians patients (38-39%), African Americans (86–89%) were more likely to live in low-SES neighborhoods, characterized by below-sample median income and education. The neighborhoods of African American cases were also more likely to have higher than median percentages of poverty, single female head of households, no car ownership, and households on public assistance.

Table 2 presents neighborhood SES indicators in association with prostate cancer severity outcomes. There were no associations of neighborhood SES with aggressive (high-stage and high-grade) tumor in this subset of cases. However, the prevalence of high-stage prostate cancer was lower in Caucasian men living in neighborhoods with high percentage of residents on public assistance (OR = 0.89, 95% CI = 0.80−0.99). No other associations with stage at diagnosis were observed.

The strongest associations between Gleason score and neighborhood SES were observed for African Americans. African Americans residing in neighborhoods with high poverty (OR = 1.39, 95% CI = 1.15−1.67), low income (OR = 1.26, 95% CI = 1.05−1.51), low educational attainment (OR = 1.34, 95% CI = 1.13−1.60), more households with no car (OR = 1.46, 95% CI = 1.20−1.78), and higher percentage of residents on public assistance (OR = 1.32, 95% CI = 1.08–1.62) had a higher Gleason score at diagnosis. Except for ≥ median percent of households with no car (OR = 1.09, 95% CI = 1.01−1.19), there were no associations of these individual neighborhood SES indicators and Gleason score among Caucasians.

3.3. Neighborhood Deprivation. Tumor aggressiveness was associated with the highest level of neighborhood deprivation in Caucasian patients only (OR = 1.27, 95% CI = 1.01−1.59). The overall *P*-value for neighborhood deprivation for this outcome was not significant ($P = 0.055$). For both Caucasians and African Americans, the highest quartile of neighborhood deprivation was associated with high Gleason score at diagnosis (OR = 1.34, 95% CI = 1.19−1.52; OR = 1.71, 95% CI = 1.21−2.40, resp.; Table 2). The overall *P*-value for neighborhood deprivation for both groups was <0.001. Trend tests were significant only for Gleason score for both Caucasian ($P \leq 0.001$) and African American patients ($P = 0.002$).

3.4. Race Effects. By conducting an unstratified analysis, we observed that African American race was significantly associated with tumor aggressiveness (OR = 1.31, $P < 0.001$), high-stage (OR = 1.27, $P < 0.001$), and high Gleason score (OR = 1.37, $P < 0.001$) at diagnosis (Table 3). The association between race and prostate cancer severity was only slightly attenuated or remained unchanged when neighborhood SES variables were included in the model. The addition of census tract variables, including the deprivation index, to the models did not change the significance level of race ($P = 0.001$) except in the model including neighborhood deprivation in association with tumor aggressiveness. In this model, the odds of patients with aggressive disease being African American was 1.20 but still significant ($P = 0.020$). The interaction between race and the neighborhood deprivation index was not statistically significant for any of the outcomes ($P = 0.170$ for aggressiveness, $P = 0.622$ for stage, and $P = 0.416$ for Gleason). Trend tests showed that increasing deprivation was associated with increased odds of high Gleason score in the combined sample ($P < 0.001$). No significant trends were observed for the other two outcomes.

4. Discussion

Our first study aim was to examine if neighborhood SES was differentially associated with prostate cancer severity comparing African American and Caucasian prostate cancer patients. We found that there were differences in observed associations for both groups. There were associations with low neighborhood SES and outcomes involving the Gleason score, primarily among African American cases. Most of these neighborhood variables measure similar SES parameters, so observed associations are expected for multiple variables and in the same direction. Although African Americans are at high risk for advanced prostate cancer, it is interesting that this particular outcome and not stage is so consistently associated with low neighborhood SES only in African Americans. This is the first report that the authors are aware of showing this difference by race and suggests that tumor grade in African Americans may be particularly prone to neighborhood influences.

Table 1: Demographics of southeastern Pennsylvania cancer registry prostate cancer patients (1995–2007).

	Caucasian ($N = 16672$)	African American ($N = 5136$)	P value
Patient-level variables			
Age at diagnosis, mean (SD)	67.6 (8.94)	66.0 (9.21)	<.001
Married	12826 (77%)	2931 (57%)	<.001
High stage (III/IV)	2040 (12%)	785 (15%)	<.001
Gleason score (7+)	3697 (22%)	1441 (28%)	<.001
Aggressive tumor	1053 (6%)	423 (8%)	<.001
Neighborhood-level variables			
≥ Median % neighborhood poverty	6381 (38%)	4582 (89%)	<.001
≥ Median % household income < $30,000	6401 (38%)	4482 (87%)	<.001
< Median % high school education	6478 (39%)	4412 (86%)	<.001
≥ Median % female head of household with dependent child(ren)	6307 (38%)	4607 (90%)	<.001
≥ Median % households with no car	6341 (38%)	4595 (89%)	<.001
≥ Median % public assistance	6319 (38%)	4583 (89%)	<.001

Table 2: Stratified analysis—associations of neighborhood SES characteristics with indicators of prostate cancer severity (GEE) adjusted for age and diagnosis year.

Effect	Tumor aggressiveness		High stage		High Gleason	
	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)
≥ Median % neighborhood poverty	0.98 (0.86, 1.12)	1.08 (0.79, 1.48)	0.92 (0.83, 1.03)	0.97 (0.78, 1.22)	1.05 (0.97, 1.14)	1.39*** (1.15, 1.67)
≥ Median % household income < $30,000	1.06 (0.93, 1.22)	0.98 (0.74, 1.29)	1.01 (0.91, 1.12)	0.99 (0.80, 1.23)	1.08 (0.99, 1.17)	1.26* (1.05, 1.51)
< Median % high school education	1.12 (0.99, 1.28)	1.14 (0.87, 1.48)	1.01 (0.91, 1.13)	1.02 (0.84, 1.24)	1.07 (0.98, 1.15)	1.34** (1.13, 1.60)
≥ Median % female head of household with dependent child(ren)	1.03 (0.90, 1.18)	0.97 (0.71, 1.32)	0.94 (0.84, 1.04)	1.00 (0.79, 1.27)	1.07 (0.99, 1.16)	1.18 (0.97, 1.44)
≥ Median % households with no car	1.02 (0.89, 1.16)	0.99 (0.74, 1.33)	0.94 (0.84, 1.04)	0.91 (0.73, 1.14)	1.09* (1.01, 1.19)	1.46*** (1.20, 1.78)
≥ Median % public assistance	0.96 (0.84, 1.10)	1.02 (0.75, 1.40)	0.89* (0.80, 0.99)	0.95 (0.76, 1.19)	1.04 (0.96, 1.13)	1.32** (1.08, 1.62)
Deprivation quartile 2 versus 1	1.04 (0.89, 1.21)	1.84 (0.98, 3.46)	0.98 (0.87, 1.11)	1.28 (0.82, 2.01)	1.05 (0.96, 1.15)	1.32 (0.89, 1.95)
Deprivation quartile 3 versus 1	0.91 (0.76, 1.08)	1.45 (0.81, 2.58)	0.90 (0.78, 1.04)	0.97 (0.65, 1.45)	1.01 (0.90, 1.13)	1.36 (0.96, 1.94)
Deprivation quartile 4 versus 1	1.27* (1.01, 1.59)	1.62 (0.93, 2.81)	0.98 (0.82, 1.18)	1.13 (0.77, 1.64)	1.34*** (1.19, 1.52)	1.71** (1.21, 2.40)
Deprivation quartile, P value	$P = 0.055$	$P = 0.227$	$P = 0.512$	$P = 0.239$	$P < .001$***	$P < .001$***

*<.05, **<.01, ***<.001.

The Gleason score may be less affected by screening practices than stage at diagnosis, and therefore may be more closely tied to biological mechanisms of prostate cancer progression. Although speculative, these mechanisms may be genetic or tied to other risk factors that are disproportionately prevalent among African Americans. Obesity is one factor that is more common in African Americans and is associated with a biologically more aggressive form of prostate cancer [15]. Obesity varies by SES factors and, therefore, may be even more relevant in the discussion of prostate cancer disparities. As African Americans are much more likely than Caucasians to live in disadvantaged areas

Table 3: Unstratified analysis—associations of neighborhood SES characteristics with indicators of prostate cancer severity (GEE) adjusted for age, race, and diagnosis year.

Effect	Tumor aggressiveness		High stage		High Gleason	
	OR (CI)	*P* value	OR (CI)	*P*-value	OR (CI)	*P*-value
African American race/ethnicity	1.31 (1.16, 1.47)	<.001	1.27 (1.17, 1.39)	<.001	1.37 (1.27, 1.47)	<.001
≥ Median % neighborhood poverty	0.99 (0.87, 1.12)	0.853	0.93 (0.84, 1.02)	0.126	1.09 (1.01, 1.17)	0.028
African American race/ethnicity	1.32 (1.15, 1.50)	<.001	1.32 (1.20, 1.46)	<.001	1.31 (1.21, 1.42)	<.001
≥ Median % household income < $30,000	1.05 (0.93, 1.19)	0.446	1.00 (0.91, 1.10)	0.998	1.10 (1.02, 1.19)	0.014
African American race/ethnicity	1.28 (1.12, 1.46)	<.001	1.27 (1.15, 1.41)	<.001	1.31 (1.20, 1.42)	<.001
< Median % high school education	1.12 (1.00, 1.27)	0.054	1.01 (0.92, 1.11)	0.802	1.10 (1.02, 1.19)	0.010
African American race/ethnicity	1.24 (1.09, 1.41)	<.001	1.27 (1.15, 1.39)	<.001	1.31 (1.21, 1.42)	<.001
≥ Median % female head of household with dependent child(ren)	1.02 (0.90, 1.16)	0.727	0.94 (0.85, 1.04)	0.217	1.09 (1.01, 1.17)	0.030
African American race/ethnicity	1.29 (1.13, 1.48)	<.001	1.31 (1.19, 1.45)	<.001	1.31 (1.21, 1.42)	<.001
≥ Median % households with no car	1.01 (0.90, 1.14)	0.845	0.93 (0.85, 1.03)	0.161	1.13 (1.05, 1.22)	0.001
African American race/ethnicity	1.30 (1.14, 1.48)	<.001	1.32 (1.19, 1.45)	<.001	1.28 (1.18, 1.40)	<.001
≥ Median % public assistance	0.97 (0.85, 1.09)	0.576	0.89 (0.81, 0.99)	0.026	1.08 (1.00, 1.16)	0.063
African American race/ethnicity	1.33 (1.17, 1.52)	<.001	1.34 (1.22, 1.49)	<.001	1.32 (1.21, 1.43)	<.001
Deprivation quartile		0.064		0.245		<.001
Deprivation quartile 2 versus 1	1.07 (0.92, 1.24)	0.390	0.99 (0.88, 1.12)	0.882	1.06 (0.98, 1.16)	0.165
Deprivation quartile 3 versus 1	0.94 (0.80, 1.11)	0.470	0.89 (0.78, 1.02)	0.083	1.03 (0.93, 1.15)	0.543
Deprivation quartile 4 versus 1	1.19 (0.99, 1.43)	0.068	0.99 (0.86, 1.14)	0.927	1.36 (1.22, 1.51)	<.001
African American race/ethnicity	1.20 (1.03, 1.39)	0.020	1.27 (1.14, 1.42)	<.001	1.16 (1.06, 1.26)	<.001

*<.05, **<.01, ***<.001.

[16], the possibility of an interaction between patient-level variables and neighborhood-level SES is possible. We were not able to test this hypothesis with the data available in this dataset.

Emerging evidence also indicates that inflammation is a probable pathway for prostate cancer progression [17]. Increased environmental stress is one pathway through which many primary neighborhood factors, such as SES, are believed to exert their effects on the body. It is still unclear what the specific ingredients of a stressful environment that could promote inflammation processes might be. However, the health-modulating effects of chronic stress have been identified as potential pathways that increase risk of disease and may be connected to general SES [18]. Psychosocial stress associated with poverty may increase the risk of many illnesses [19]. In anticipation of an impending challenge, stress that may have been acute (adaptive for our bodies) becomes chronic (pathogenic for our bodies). A prolonged

stress response ultimately results in suppressed immunity and impairs disease defenses. Stress can affect reproductive hormones and immune responses. Cellular and molecular events that promote cancer growth also are affected by stress, and DNA repair mechanisms may be impaired because of stress and cancer defense mechanisms may be disrupted. Stress may influence the expression of viral oncogenes and the replication of tumorigenic viruses. It may also promote tumor growth by facilitating the development of blood supply to the tumor [19].

Differential exposure to stressors may explain a portion of health disparities that we observe by both race and neighborhood SES. Residential neighborhood factors may capture structural and social context that influence overall health and related behavior. Neighborhood deprivation, deterioration, urbanization, poverty, education, segregation, social disorder, and income have been correlated with disease rates and health outcomes [20–28].

We also observed a single inverse association of neighborhood public assistance on stage at diagnosis in Caucasian patients. This finding was unexpected, as it is the only significant, protective relationship observed in these analyses. This neighborhood variable has not been studied in the context of prostate cancer staging or screening. Patient-level data suggests that subsets of patients on Medicaid are at increased risk for late prostate cancer diagnosis [29]. Therefore, it is not clear why our Caucasian subset would be at lower risk for advanced disease if they reside in lower SES neighborhoods.

Income and education are commonly used in the US as measure of patient- and neighborhood-level SES. Both income and educational attainment have been shown to affect risk for cancer diagnosis. A study using the New Jersey Cancer Registry observed clusters of prostate cancer incidence to be associated with geographic areas with higher percentages of foreign-born persons, higher poverty, and lower education [30]. According to SEER data, higher educational attainment has been associated with greater risk of prostate and breast cancers alike. Compared to college-educated men, men with less than a college education were 0.79 as likely to be diagnosed with prostate cancer. Low-income men (family income $<$ \$25,000) were also at lower risk for prostate cancer compared to men with a family income of \$50,000+ [31]. Prostate screening (and therefore prostate incidence) has been shown to be more common in men with higher education, white collar jobs, access to good healthcare, urban residences, and higher household income [32]. A similar positive association between neighborhood SES and breast cancer screening behavior has been observed, even after adjusting for distance to screening facility, urban-rural status, and type of screening facility [33]. Both zip code community SES and zip code urbanicity are positively associated with breast cancer incidence, even after adjusting for individual education [27].

Although, in general, high SES may be associated with prostate cancer incidence/diagnosis, low-SES is associated with more severe disease at diagnosis, suggesting more likely progression and increased risk of cancer-related mortality. Associations between lower neighborhood SES and advanced stage or grade at diagnosis have been observed previously. Lower income has been associated with late-stage prostate cancer diagnosis in the SEER dataset ($P = 0.002$) [31]. Klassen et al. found that subsets of Caucasian men living in high-income areas were at particular low-risk for aggressive prostate tumors [34]. A prostate cancer study in Australia showed that three-year survival was poorer and use of radical prostatectomy was less in men from socioeconomically and geographically disadvantaged backgrounds [35]. Results from the ARIC Study showed that rates of all-cause death, cardiovascular death, and cancer death were greater for men and women living in the lowest income bracket compared to those in the highest [22]. A multilevel study using Florida state data coupled with medical records demonstrated that in addition to individual factors such as Black race, single marital status, current and former smoking status, and older age, advanced prostate cancer was significantly associated with living in census tracts with a low median income and lower percent of residents with a college education [36]. Our study also showed that African American race remained significant even after including neighborhood SES factors in multivariable analysis.

In addition to single variable associations, neighborhood indices representing socioeconomic disadvantage have been associated with various health outcomes [11]. In our study, we found that Caucasians and African Americans in more deprived neighborhoods were more likely to be diagnosed with high-grade prostate cancer. Consistency of these findings with regard to outcomes involving tumor grade may suggest that the deprivation index captures underlying factors of neighborhood SES that together contribute to advanced prostate cancer risk across ethnic groups. Highest levels of neighborhood deprivation were significantly associated with tumor grade in both ethnic groups. To date, few studies have used a deprivation index to examine prostate cancer severity and/or outcomes. One in the UK found that patients from more deprived neighborhoods were more likely than men from less deprived areas to be diagnosed with late stage (stage III or IV) prostate cancer. As in our study, more deprived patients were older. In multivariable analysis, increased deprivation was significantly associated with lower odds of radiation therapy (OR = 0.92, CI = 0.90−0.94) and surgery (OR = 0.90, 95% CI = 0.87−0.94) [37]. A study of the California Cancer Registry used a composite SES score to evaluate treatment outcomes in prostate cancer patients. Men from low-SES areas that were treated by surgery or radiation had increased odds of cancer-specific death. Men from lower SES areas were also half as likely to undergo radical prostatectomy for low-risk disease. Adjusting for race made these findings even more profound. Together, these results may suggest the need for improved screening and treatment in men from low-SES communities [38].

4.1. Study Limitations and Strengths. The limitations of our study include the fact that the cut-points between more and less advantaged neighborhoods are arbitrary and dependent upon our sample characteristics. However, using the deprivation index to examine neighborhood SES will make this study more comparable to future studies that use similar methods. In addition, our study investigated only census

tract-level SES variables, ignoring other contextual characteristics that vary by family, social networks, workplace, and other levels of socially/physically bounded measures of community/geography. We may also be limited by the "intersection of racial and SES segregation," in which there are relatively few African Americans in the least deprived areas and few Caucasians in the most deprived areas [11]. However, among study areas in the study by Messer et al., Philadelphia showed the largest range in deprivation scores [11]. Therefore, studying the Greater Philadelphia area may have provided an opportunity to observe the effects of neighborhood deprivation better than we could have in other urban populations.

Another limitation of this study is that we were unable to determine the length of time at residency and if there are modifying effects that result from duration of exposure [39]. We do not yet know when neighborhood factors are most likely to contribute to cancer outcomes (during childhood or adolescence, during the period before clinical disease onset or after treatment). We also do not know much about the period of time that is required for a particular neighborhood exposure or set of exposures to affect the biology and progression/recurrence of disease in an individual with prostate cancer [40]. Factors like neighborhood SES can be measured at various time points during the lifespan. The relative time frame depends on presumed exposures, causal pathways, and associated etiologic periods [41]. Thus, we have decided to begin our investigation at the point of prostate cancer diagnosis. This allows us to be consistent across all patients. It also provides a sensible timeframe that may be closely linked to the lifestyle and environmental factors that are most likely to influence prostate cancer progression and outcomes. We were unable to evaluate other patient-level variables related to lifestyle and treatment because we were limited by the data collected by the PA Department of Health for these analyses.

A particular strength of this study is the use of a standardized deprivation scoring system. The use of different and multiple definitions of variables used in previous prostate cancer studies made it difficult to assess the evidence for associations systematically. However, the fact that we find similar associations with prostate cancer when multiple definitions of neighborhood SES are used suggests the validity of these findings across studies and populations. Composite variables are also less likely to be significantly influenced by changes in single contributing variables over time. In addition, making conclusions based on one neighborhood SES factor without considering the status of other related contextual variables may lead to inappropriate conclusions [11]. We were also able to determine relationships between neighborhood deprivation and prostate cancer severity by race. Other studies of neighborhood deprivation and prostate cancer severity have not had the diversity to examine patterns of association stratified by race [42] or have only adjusted for ethnicity in multivariable analyses [38]. Evidence of an association between the environment and prostate cancer outcomes can increase our knowledge about risk factors for prostate cancer and stimulate new ideas about prevention strategies. This research also may identify segments of the population that may benefit from targeting interventions. Because prostate cancer is so common in the general population, even if only a small increased risk of disease is associated with it, the potential for decreasing the overall morbidity and mortality attributable to neighborhood deprivation may be significant.

5. Conclusions

The goal of this study was to examine the relationship between neighborhood SES or deprivation and prostate cancer severity in a diverse population of patients representing the general population of Southeastern Pennsylvania. We found significant differences in neighborhood SES by race. We also observed differences in prostate cancer severity by neighborhood SES and higher degree of neighborhood deprivation. The associations were strongest and most consistent for African Americans.

The science of studying health disparities and neighborhood characteristics (from appropriate methods and models to proper outcome measures and results interpretation) is still young. Future analyses examining this deprivation index in other ethnic groups and in multilevel models may help to determine the effect of neighborhood SES on prostate cancer outcomes. Understanding which neighborhood-level variables best predict poor health outcomes in different environmental settings may aid all researchers in unraveling the complexities of prostate cancer disparities in America.

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Supporting Data

Table 1: Number of Crimes Reported in Philadelphia Census Tracts -- Representing PA Cancer Registry Prostate Cancer Patients Residing in Philadelphia County at Time of Prostate Cancer Diagnosis (1995-2005)

Crimes per census tract (median)	Crime Variable	Crime year	Prostate Cancer Outcome	Race		p-value
				Caucasian (n=4225)	African-American (n=4639)	
# all crimes		2000		222 (sd=144.4)	248 (sd=118.2)	**<0.001**
# aggressive assaults		2000		13 (sd=22.0)	36 (sd=28.2)	**<0.001**
# aggressive assaults with gun		2000		2 (sd=8.6)	15 (sd=12.5)	**<0.001**
# all thefts		2000		111 (sd=107.5)	112 (sd=69.7)	**<0.001**
# graffiti vandalisms		2000		2 (sd=4.4)	0 (sd=1.5)	**<0.001**
# vandalisms and criminal mischief		2000		66 (sd=40.2)	60 (sd=66.8)	**<0.001**

Table 2: Median Number of Crimes Reported in Philadelphia Census Tracts by Deprivation Quartile -- Representing PA Cancer Registry Prostate Cancer Patients Residing in Philadelphia County at Time of Prostate Cancer Diagnosis (1995-2005)

Crimes per census tract (median)	Crime year	Quartile 1	Quartile2	Quartile3	Quartile 4	p-value
# all crimes	2000	23	97	170	262	**<0.001**
# aggressive assaults	2000	1	4	10	40	**<0.001**
# aggressive assaults with gun	2000	0	1	2	15	**<0.001**
# all thefts	2000	14	66	94	121	**<0.001**
# graffiti vandalisms	2000	0	2	2	1	**<0.001**
# vandalisms and criminal mischief	2000	5	34	54	72	**<0.001**

Table 3: Demographics of SCORE prostate cancer patients (1995-2011)

	Caucasian (N=887)	African American (N=207)	p-value
Patient-level variables			
Age at diagnosis, mean (SD)	61.9 (7.6)	61.6 (8.5)	0.357
Married	87.3%	75.3%	<0.001
High stage (III/IV)	25.5%	26.9%	0.711
Gleason score (7+)	51.8%	57.3%	0.229
Aggressive tumor	20.08%	23.42%	0.334
Neighborhood-level variables			
≥ Median % neighborhood poverty	40.1%	81.9%	<0.001
≥ Median % household income < $30,000	40.9%	86.8%	<0.001
≤ Median % high school education	42.5%	85.3%	<0.001
≥ Median % female head of household with dependent child(ren)	41.9%	87.8%	<0.001
≥ Median % households with no car	41.3%	85.8%	<0.001
≥ Median % public assistance	40.9%	87.8%	<0.001

Table 4: Stratified Analysis – associations of neighborhood SES characteristics with indicators of prostate cancer severity (GEE) adjusted for age and diagnosis year.

Effect	Tumor Aggressiveness		High Stage		High Gleason		Age 65+ at Diagnosis	
	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)
≥ Median % neighborhood poverty	0.96 (0.67-1.37)	3.21 (0.98-10.55)	0.88 (0.64-1.20)	1.63 (0.63-4.18)	1.05 (0.78-1.39)	2.16 (0.98-4.74)	0.86 (0.63-1.19)	1.26 (0.59-2.67)
≥ Median % household income < $30,000	1.16 (0.80-1.66)	1.98 (0.63-6.26)	1.06 (0.78-1.46)	1.32 (0.49-3.56)	1.21 (0.90- 1.62)	1.26 (0.53-3.00)	0.79 (0.57-1.09)	1.52 (0.53-4.31)
≤ Median % high school education	0.92 (0.64-1.34)	3.15 (0.88-11.24)	0.93 (0.68-1.28)	1.17 (0.46-2.99)	1.13 (0.85-1.51)	1.88 (0.80-4.42)	**0.62 (0.46-0.86)**	0.87 (0.35-2.15)
≥ Median % female head of household with dependent child(ren)	0.89 (0.62-1.29)	1.19 (0.40-3.50)	1.02 (0.74-1.40)	0.73 (0.29-1.86)	1.16 (0.87-1.54)	1.34 (0.53-3.40)	0.73 (0.53-1.00)	2.37 (0.84-6.73)
≥ Median % households with no car	0.90 (0.62-1.30)	2.18 (0.70-6.77)	0.79 (0.58-1.08)	1.97 (0.70-5.60)	1.12 (0.83-1.49)	1.46 (0.62-3.47)	0.99 (0.72-1.35)	1.52 (0.58-3.93)
≥ Median % public assistance	1.08 (0.75-1.54)	1.19 (0.41-3.47)	1.08 (0.79-1.49)	0.74 (0.30-1.83)	0.97 (0.73-1.29)	2.53 (0.99-6.47)	**0.67 (0.49-0.93)**	1.96 (0.77-4.95)

Deprivation quartile 2 versus 1*	1.01 (0.66-1.55)	1.00 (0.20-4.98)	1.03 (0.73-1.48)	1.27 (0.29-5.58)	1.25 (0.89-1.74)	1.44 (0.34-6.07)	0.84 (0.58-1.21)	2.32 (0.58-9.30)
Deprivation quartile 3 versus 1*	0.99 (0.79-1.26)	1.05 (0.49-2.27)	0.96 (0.78-1.19)	0.95 (0.47-1.92)	1.06 (0.87-1.29)	1.33 (0.69-2.56)	0.83 (0.67-1.03)	1.83 (0.99-3.37)
Deprivation quartile 4 versus 1*	1.11 (0.82-1.53)	1.28 (0.82-2.00)	1.07 (0.82-1.38)	1.13 (0.76-1.70)	0.96 (0.73-1.27)	1.15 (0.80-1.67)	0.89 (0.67-1.18)	1.24 (0.84-1.85)
≥ Median % Aggressive Gun Assaults	1.00 (0.41-2.44)	0.66 (0.28-1.57)	1.42 (0.75-2.68)	0.71 (0.27-1.85)	0.69 (0.33-1.47)	2.00 (0.94-4.26)	0.48 (0.20-1.18)	0.80 (0.28-2.33)
≥ Median % Graffiti Reports	0.79 (0.26-2.34)	1.10 (0.47-2.54)	0.46 (0.20-1.07)	0.81 (0.35-1.87)	0.94 (0.39-2.27)	**2.39 (1.17-4.90)**	0.47 (0.22-1.02)	0.73 (0.33-1.61)
≥ Median % Vandalism and Criminal Mischief	1.16 (0.44-3.01)	**2.40 (1.03-5.58)**	0.91 (0.44-1.91)	2.18 (0.94-5.10)	0.82 (0.39-1.74)	1.08 (0.52-2.24)	1.09 (0.51-2.33)	0.79 (0.38-1.65)

*Deprivation quartiles were created from population-based deprivation calculations from Southeastern Pennsylvania (Zeigler-Johnson, et al. 2011)

Table 5: PA Cancer Registry Stratified Analysis – associations of neighborhood SES characteristics with indicators of prostate cancer severity (GEE) adjusted for age and diagnosis year.

Effect	Tumor Aggressiveness		High Stage		High Gleason		Age 65+ at Diagnosis**	
	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)	Caucasian OR (95% CI)	African American OR (95% CI)
≥ Median % neighborhood poverty	0.98 (0.86-1.12)	1.08 (0.79-1.48)	0.92 (0.83-1.03)	0.97 (0.78-1.22)	1.05 (0.97-1.14)	**1.39 (1.15-1.67)**	**1.17 (1.06-1.29)**	**1.34 (1.06-1.70)**
≥ Median % household income < $30,000	1.06 (0.93-1.22)	0.98 (0.74-1.29)	1.01 (0.91-1.12)	0.99 (0.80-1.23)	1.08 (0.99-1.17)	**1.26 (1.05-1.51)**	**1.28 (1.19-1.39)**	**1.31 (1.10-1.56)**
≤ Median % high school education	1.12 (0.99-1.28)	1.14 (0.87-1.48)	1.01 (0.91-1.13)	1.02 (0.84-1.24)	1.07 (0.98-1.15)	**1.34 (1.13-1.60)**	**1.21 (1.10-1.33)**	**1.32 (1.07-1.63)**
≥ Median % female head of household with dependent child(ren)	1.03 (0.90-1.18)	0.97 (0.71-1.32)	0.94 (0.84-1.04)	1.00 (0.79-1.27)	1.07 (0.99-1.16)	1.18 (0.97-1.44)	**1.15 (1.07-1.27)**	**1.32 (1.04-1.67)**
≥ Median % households with no car	1.02 (0.89-1.16)	0.99 (0.74-1.33)	0.94 (0.84-1.04)	0.91 (0.73-1.14)	**1.09 (1.01-1.19)**	**1.46 (1.20-1.78)**	**1.32 (1.20-1.45)**	**1.23 (0.97-1.56)**
≥ Median % public assistance	0.96 (0.84-1.10)	1.02 (0.75-1.40)	**0.89 (0.80-0.99)**	0.95 (0.76-1.19)	1.04 (0.96-1.13)	**1.32 (1.08-1.62)**	**1.18 (1.09-1.28)**	**1.27 (1.05-1.54)**

Deprivation quartile 2 versus 1*	1.04 (0.89-1.21)	1.84 (0.98-3.46)	0.98 (0.87-1.11)	1.28 (0.82-2.01)	1.05 (0.96-1.15)	1.04 (0.89-1.21)	**1.26 (1.15-1.38)**	1.20 (0.86-1.66)
Deprivation quartile 3 versus 1*	0.91 (0.76-1.08)	1.45 (0.81-2.58)	0.90 (0.78-1.04)	0.97 (0.65-1.45)	1.01 (0.90-1.13)	1.36 (0.96-1.94)	**1.20 (1.13-1.26)**	1.10 (0.96-1.27)
Deprivation quartile 4 versus 1*	**1.27 (1.01-1.59)**	1.62 (0.93-2.81)	0.98 (0.82-1.18)	1.13 (0.77-1.64)	**1.34 (1.19-1.52)**	**1.71 (1.21-2.40)**	**1.12 (1.07-1.17)**	**1.18 (1.08-1.28)**
≥ Median % Aggressive Gun Assaults	**1.44 (1.23-1.69)**	1.06 (0.93-1.22)	**1.35 (1.08-1.68)**	1.04 (0.87-1.24)	**1.53 (1.29-1.81)**	1.08 (0.94-1.25)	1.00 (0.85-1.18)	**1.17 (0.97-1.40)**
≥ Median % Graffitti Reports	0.96 (0.78-1.17)	0.91 (0.87-1.20)	0.92 (0.71-1.20)	0.92 (0.78-1.08)	1.00 (0.81-1.23)	0.90 (0.79-1.04)	0.91 (0.73-1.12)	**0.87 (0.73-1.03)**
≥ Median % Vandalism and Criminal Mischief	1.03 (0.87-1.20)	0.99 (0.88-1.12)	1.04 (0.85-1.28)	1.00 (0.85-1.17)	1.03 (0.87-1.22)	1.00 (0.87-1.14)	0.96 (0.82-1.12)	1.02 (0.87-1.21)

*Deprivation quartiles were created from population-based deprivation calculations from Southeastern Pennsylvania (Zeigler-Johnson, et al. 2011)
** Models do not include age at diagnosis

Table 6: Multi-Level Analysis – associations of neighborhood SES characteristics with indicators of prostate cancer severity (GEE) adjusted for age and diagnosis year.

Model	Outcome	Neighborhood Variables	Patient-Level Variables	Caucasian OR (95% CI)	African-American (95% CI)
I	Age 65+ at diagnosis	High % median Poverty		0.97 (0.67-1.40)	**1.36 (0.47-3.96)
			High School education	0.56 (0.13-2.42)	**0.65 (0.18-2.33)
			College education	0.72 (0.16-3.12)	**0.41 (0.11-1.57)
			Post-graduate education	0.88 (0.20-3.84)	**0.62 (0.16-2.38)
			PSA (ng/ml)	1.02 (1.00-1.05)	**1.02 (0.96-1.08)
			Family History of Prostate Cancer	0.85 (0.60-1.19)	**1.84 (0.78-4.32)
			Married	**2.24 (1.22-4.09)**	**2.25 (0.71-7.09)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.74-0.90)**
II		High % median income<$30,000		0.94 (0.65-1.37)	**1.49 (0.38-5.85)
			High School education	0.56 (0.13-2.46)	**0.61 (0.18-2.11)
			College education	0.72 (0.16-3.18)	**0.41 (0.11-1.51)
			Post-graduate education	0.87 (0.20-3.87)	**0.60 (0.16-2.26)
			PSA (ng/ml)	1.02 (1.00-1.05	**1.02 (0.96-1.08)
			Family History of Prostate	0.84 (0.59-1.18)	**1.84 (0.79-4.29)

			Cancer		
			Married	**2.24 (1.22-4.09)**	**2.16 (0.73-6.39)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.74-0.91)**
III		Low % HS education		0.78 (0.54-1.13)	**0.98 (0.30-3.22)
			High School education	0.56 (0.13-2.45)	**0.60 (0.18-2.06)
			College education	0.68 (0.15-2.98)	**0.37 (0.10-1.42)
			Post-graduate education	0.82 (0.19-3.60)	**0.57 (0.15-2.16)
			PSA (ng/ml)	1.02 (1.00-1.05)	**1.01 (0.96-1.08)
			Family History of Prostate Cancer	0.83 (0.59-1.18)	**1.84 (0.79-4.30)
			Married	**2.20 (1.20-4.05)**	**2.12 (0.70-6.39)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.74-0.91)**
IV		High % Female Head of Household		1.00 (0.69-1.45)	**2.29 (0.60-8.72)
			High School education	0.56 (0.13-2.42)	**0.65 (0.19-2.28)
			College education	0.72 (0.17-3.14)	**0.44 (0.12-1.66)
			Post-graduate education	0.89 (0.20-3.88)	**0.67 (0.17-2.61)
			PSA (ng/ml)	1.02 (1.00-1.05)	**1.02 (0.96-1.08)
			Family History	0.85 (0.60-1.20)	**1.86 (0.78-4.42)

			of Prostate Cancer		
			Married	**2.26 (1.22-4.16)**	**2.30 (0.74-7.11)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.74-0.91)**
V		High % No car		0.91 (0.63-1.31)	**1.79 (0.46-6.87)
			High School education	0.55 (0.13-2.40)	**0.64 (0.18-2.21)
			College education	0.70 (0.16-3.06)	**0.45 (0.12-1.73)
			Post-graduate education	0.87 (0.19-3.77)	**0.62 (0.16-2.41)
			PSA (ng/ml)	1.02 (1.00-1.05)	**1.02 (0.96-1.08)
			Family History of Prostate Cancer	0.84 (0.60-1.19)	**1.87 (0.80-4.39)
			Married	**2.21 (1.21-4.05)**	**2.23 (0.75-6.67)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.73-0.91)**
VI		High % Public Assistance		**0.66 (0.46-0.94)**	**2.01 (0.50-8.03)
			High School education	0.53 (0.12-2.27)	**0.64 (0.18-2.23)
			College education	0.65 (0.15-2.81)	**0.43 (0.11-1.59)
			Post-graduate education	0.78 (0.18-3.39)	**0.64 (0.16-2.50)
			PSA (ng/ml)	1.02 (1.00-1.05)	**1.02 (0.96-1.08)
			Family History of Prostate	0.83 (0.57-1.18)	**1.90 (0.80-4.52)

			Cancer		
			Married	**2.16 (1.18-3.98)**	**2.29 (0.75-7.04)
			Year of diagnosis (years)	**0.91 (0.88-0.95)**	****0.82 (0.74-0.91)**
VII		High % gun assaults/		**0.23 (0.08-0.66)**	1.11 (0.23-5.33)
		High % graffiti		0.46 (0.15-1.37)	0.89 (0.35-2.25)
		High % vandalism and criminal mischief		2.98 (0.97-9.19)	0.87 (0.42-1.81)
			High School education	2.07 (0.16-26.09)	0.67 (0.14-3.00)
			College education	2.70 (0.20-35.86)	0.26 (0.05-1.34)
			Post-graduate education	6.03 (0.42-85.92)	0.29 (0.06-1.51)
			PSA (ng/ml)	1.04 (0.96-1.12)	1.02 (0.96-1.09)
			Family History of Prostate Cancer	0.57 (0.24-1.35)	1.41 (0.44-4.47)
			Married	1.63 (0.56-4.72)	2.60 (0.66-10.34)
			Year of diagnosis (years)	**0.88 (0.80-0.97)**	**0.85 (0.75-0.97)**
VIII		Deprivation Quartile 2		0.79 (0.53-1.18)	**3.27 (0.47-22.84)
		Deprivation Quartile 3		0.77 (0.46-1.29)	**2.64 (0.49-14.26)
		Deprivation Quartile 4		0.79 (0.28-2.24)	**2.00 (0.37-10.83)
			High School	0.56 (0.13-2.46)	**0.58 (0.16-2.14)

			education		
			College education	0.69 (0.16-3.04)	**0.41 (0.10-1.60)
			Post-graduate education	0.84 (0.19-3.68)	**0.58 (0.14-2.31)
			PSA (ng/ml)	1.02 (1.00-1.06)	**1.02 (0.95-1.08)
			Family History of Prostate Cancer	0.83 (0.59-1.18)	**1.86 (0.78-4.41)
			Married	**2.17 (1.18-3.99)**	**2.26 (0.70-7.28)
			Year of diagnosis (years)	**0.92 (0.88-0.96)**	****0.82 (0.73-0.91)**
I	Tumor Stage	High % median Poverty		0.84 (0.58-1.22)	0.67 (0.19-2.34)
			High School education	5.34 (0.53-54.00)	1.31 (0.23-7.61)
			College education	4.38 (0.44-44.00)	1.28 (0.22-7.39)
			Post-graduate education	4.88 (0.48-49.15)	1.13 (0.24-5.24)
			PSA (ng/ml)	**1.05 (1.01-1.08)**	**1.20 (1.10-1.30)**
			Family History of Prostate Cancer	**1.54 (1.05-2.24)**	1.21 (0.54-2.70)
			Married	1.00 (0.58-1.73)	**0.29 (0.10-0.84)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.96-1.14)
II		High % median income<$30,000		0.93 (0.65-1.34)	0.53 (0.17-1.64)
			High School	5.27 (0.54-51-34)	1.38 (0.24-7.89)

			education		
			College education	4.40 (0.45-42.49)	1.26 (0.23-6.83)
			Post-graduate education	4.79 (0.49-46.40)	1.13 (0.26-4.95)
			PSA (ng/ml)	**1.05 (1.01-1.09)**	**1.20 (1.10-1.31)**
			Family History of Prostate Cancer	**1.53 (1.04-2.24)**	1.21 (0.54-2.72)
			Married	1.03 (0.60-1.75)	**0.29 (0.10-0.81)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.95-1.14)
III		Low % HS education		0.87 (0.59-1.27)	0.74 (0.24-2.32)
			High School education	5.41 (0.54-54.35)	1.38 (0.25-7.70)
			College education	4.35 (0.44-43.32)	1.35 (0.25-7.20)
			Post-graduate education	4.81 (0.48-48.01)	1.18 (0.27-5.18)
			PSA (ng/ml)	**1.05 (1.01-1.08)**	**1.19 (1.10-1.30)**
			Family History of Prostate Cancer	**1.53 (1.05-2.24)**	1.18 (0.53-2.64)
			Married	1.02 (0.60-1.75)	**0.29 (0.10-0.84)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.96-1.14)
IV		High % Female Head of Household		0.89 (0.61-1.30)	**0.27 (0.09-0.81)**

			High School education	5.37 (0.53-53.57)	1.23 (2.15-7.06)
			College education	4.35 (0.44-42.96)	0.95 (0.17-5.42)
			Post-graduate education	4.87 (0.49-48-30)	0.87 (0.19-4.02)
			PSA (ng/ml)	**1.04 (1.01-1.08)**	**1.20 (1.11-1.31)**
			Family History of Prostate Cancer	**1.55 (1.06-2.26)**	1.35 (0.58-3.13)
			Married	1.03 (0.60-1.75)	**0.26 (0.09-0.78)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.95-1.14)
V		High % No car		0.65 (0.45-0.93)	1.05 (0.29-3.78)
			High School education	5.34 (0.46-61.99)	1.40 (0.25-7.78)1
			College education	4.21 (0.36-48.64)	1.48 (0.26-8.34)
			Post-graduate education	4.65 (0.40-54.00)	1.25 (0.27-5.66)
			PSA (ng/ml)	**1.05 (1.02-1.09)**	**1.19 (1.10-1.30)**
			Family History of Prostate Cancer	**1.52 (1.04-2.22)**	1.19 (0.53-2.64)
			Married	0.96 (0.55-1.66)	**0.31 (0.11-0.86)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.95-1.13)
VI		High % Public Assistance		1.07 (0.75-1.53)	**0.31 (0.10-0.98)**
			High School	5.25 (0.57-48.24)	1.23 (0.22-6.97)

			education		
			College education	4.48 (0.49-40.96)	1.08 (0.20-5.81)
			Post-graduate education	4.93 (0.54-45.19)	0.90 (0.20-4.05)
			PSA (ng/ml)	**1.05 (1.01-1.09)**	**1.20 (1.10-1.30)**
			Family History of Prostate Cancer	**1.53 (1.04-2.25)**	1.21 (0.54-2.74)
			Married	1.05 (0.62-1.79)	**0.25 (0.08-0.73)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.95-1.13)
VII		High % gun assaults/		**1.50 (0.51-4.45)	0.27 (0.07-1.00)
		High % graffiti		**0.62 (0.21-1.89)	0.59 (0.19-1.84)
		High % vandalism and criminal mischief		**1.20 (0.37-3.88)	2.82 (0.95-8.39)
			High School education	**0.89 (0.60-7.81)	0.78 (0.11-5.67)
			College education	**0.50 (0.04-5.67)	**0.98 (0.11-8.50)**
			Post-graduate education	**0.52 (0.05-5.75)	0.45 (0.08-2.55)
			PSA (ng/ml)	**1.03 (0.94-1.13)	**1.15 (1.06-1.24)**
			Family History of Prostate Cancer	****4.72 (1.75-12.81)**	2.58 (0.93-7.14)
			Married	**0.59 (0.20-1.69)	**0.14 (0.03-0.64)**
			Year of diagnosis	****0.88 (0.77-0.99)**	0.92 (0.82-1.02)

			(years)		
VIII		Deprivation Quartile 2		0.96 (0.63-1.44)	0.54 (0.11-2.59)
		Deprivation Quartile 3		0.80 (0.49-1.32)	0.16 (0.02-1.24)
		Deprivation Quartile 4		0.83 (0.31-2.22)	0.53 (0.13-2.20)
			High School education	5.37 (0.53-54.85)	1.59 (0.30-8.47)
			College education	4.39 (4.35-44.34)	1.19 (0.21-6.60)
			Post-graduate education	4.78 (0.47-48.35)	1.47 (0.34-6.43)
			PSA (ng/ml)	**1.05 (1.01-1.09)**	**1.23 (1.12-1.34)**
			Family History of Prostate Cancer	**1.52 (1.04-2.23)**	1.23 (0.54-2.82)
			Married	0.99 (0.57-1.71)	**0.29 (0.10-0.83)**
			Year of diagnosis (years)	0.98 (0.94-1.02)	1.04 (0.95-1.13)
I	Tumor Grade	High % median Poverty		0.91 (0.64-1.29)	1.78 (0.68-4.67)
			High School education	0.29 (0.06-1.48)	0.71 (0.15-3.40)
			College education	0.26 (0.05-1.35)	0.59 (0.13-2.65)
			Post-graduate education	0.20 (0.04-1.05)	0.84 (0.16-4.38)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.09 (0.98-1.20)
			Family History	1.08 (0.77-1.51)	0.92 (0.39-2.18)

			of Prostate Cancer		
			Married	1.21 (0.73 – 2.00))	1.18 (0.47-2.95)
			Year of diagnosis (years)	1.03 (0.99-1.06)	1.10 (1.00-1.20)
II		High % median income<$30,000		1.07 (0.76-1.51)	0.89 (0.31-2.61)
			High School education	0.29 (0.06-1.47)	0.63 (0.13-3.05)
			College education	0.27 (0.05-1.39)	0.45 (0.10-2.01)
			Post-graduate education	0.21 (0.04-1.08)	0.71 (0.14-3.69)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.10 (0.99-1.22)
			Family History of Prostate Cancer	1.09 (0.78-1.52)	0.95 (0.40-2.22)
			Married	1.25 (0.76-2.05)	1.06 (0.42-2.65)
			Year of diagnosis (years)	1.03 (1.00-1.06)	**1.11 (1.02-1.21)**
III		Low % HS education		1.04 (0.73-1.49)	1.49 (0.50-4.48)
			High School education	0.29 (0.06-1.44)	0.63 (0.13-3.10)
			College education	0.27 (0.06-1.36)	0.52 (0.11-2.37)
			Post-graduate education	0.21 (0.04-1.08)	0.76 (0.15-3.90)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.09 (0.98-1.21)
			Family History	1.09 (0.78-1.52)	0.94 (0.40-2.21)

			of Prostate Cancer		
			Married	1.25 (0.76-2.04)	1.14 (0.45-2.85)
			Year of diagnosis (years)	1.03 (1.00-1.06)	**1.10 (1.01-1.20)**
IV		High % Female Head of Household		1.03 (0.73-1.46)	1.22 (0.38-3.93)
			High School education	0.29 (0.06-1.46)	0.64 (0.13-3.15)
			College education	0.27 (0.05-1.37)	0.49 (0.11-2.27)
			Post-graduate education	0.21 (0.04-1.07)	0.78 (0.15-3.95)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.09 (0.98-1.21)
			Family History of Prostate Cancer	1.08 (0.77-1.52)	0.92 (0.39-2.20)
			Married	1.24 (0.76-2.04)	1.08 (0.43-2.71)
			Year of diagnosis (years)	1.03 (1.00-1.06)	**1.11 (1.01-1.20)**
V		High % No car		1.07 (0.77-1.50)	1.45 (0.44-4.82)
			High School education	0.30 (0.06-1.48)	0.65 (0.13-3.15)
			College education	0.27 (0.05-1.38)	0.54 (0.11-2.53)
			Post-graduate education	0.21 (0.04-1.07)	0.77 (0.15-3.94)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.09 (0.98-1.21)
			Family History	1.09 (0.78-1.52)	0.94 (0.40-2.20)

			of Prostate Cancer		
			Married	1.26 (0.77-2.06)	1.13 (0.45-2.82)
			Year of diagnosis (years)	1.03 (1.00-1.06)	**1.10 (1.01-1.20)**
VI		High % Public Assistance		0.86 (0.62-1.20)	2.14 (0.63-7.22)
			High School education	0.28 (0.06-1.38)	0.67 (0.14-3.25)
			College education	0.25 (0.05-1.24)	0.55 (0.12-2.46)
			Post-graduate education	**0.19 (0.04-0.96)**	0.86 (0.16-4.59)
			PSA (ng/ml)	**1.09 (1.04-1.16)**	1.09 (0.98-1.22)
			Family History of Prostate Cancer	1.11 (0.79-1.55)	0.94 (0.40-2.21)
			Married	1.22 (0.74-2.01)	1.18 (0.47-2.99)
			Year of diagnosis (years)	1.03 (0.99-1.06)	**1.11 (1.01-1.21)**
VII		High % gun assaults/		**0.36 (0.14-0.96)**	1.93 (0.41-9.11)
		High % graffiti		0.85 (0.30-2.38)	**3.88 (1.05-14.41)**
		High % vandalism and criminal mischief		1.22 (0.46-3.25)	**0.25 (0.07-0.92)**
			High School education	---	1.16 (0.16-8.18)
			College education	---	0.35 (0.05-2.41)

			Post-graduate education	---	0.91 (0.12-6.76)
			PSA (ng/ml)	1.16 (1.00-1.35)	**1.13 (1.01-1.26)**
			Family History of Prostate Cancer	1.01 (0.40-2.57)	1.02 (0.36-2.94)
			Married	0.96 (0.38-2.41)	1.23 (0.42-3.59)
			Year of diagnosis (years)	1.03 (0.95-1.12)	1.10 (0.97-1.24)
VIII		Deprivation Quartile 2		1.08 (0.74-1.56)	0.82 (0.13-5.12)
		Deprivation Quartile 3		1.01 (0.63-1.62)	0.96 (0.21-4.30)
		Deprivation Quartile 4		0.57 (0.20-1.61)	1.06 (0.26-4.40)
			High School education	0.30 (0.06-1.51)	0.65 (0.13-3.30)
			College education	0.28 (0.05-1.41)	0.47 (0.10-2.33)
			Post-graduate education	0.21 (0.04-1.09)	0.77 (0.13-4.41)
			PSA (ng/ml)	**1.09 (1.03-1.16)**	1.10 (0.98-1.23)
			Family History of Prostate Cancer	1.09 (0.78-1.53)	0.93 (0.40-2.21)
			Married	1.19 (0.71-1.98)	1.08 (0.43-2.73)
			Year of diagnosis (years)	1.03 (0.99-1.06)	**1.11 (1.01-1.21)**
I	Tumor Aggressiveness	High % median Poverty		0.81 (0.53-1.24)	1.09 (0.31-3.91)

			High School education	3.25 (0.20-51.73)	1.91 (0.27-13.55)
			College education	3.05 (0.19-48.46)	1.96 (0.26-14.67)
			Post-graduate education	3.24 (0.20-51.36)	0.44 (0.03-6.74)
			PSA (ng/ml)	1.07 (1.03-1.11)	**1.16 (1.07-1.25)**
			Family History of Prostate Cancer	1.26 (0.83-1.92)	0.83 (0.32-2.18)
			Married	1.47 (0.75-2.91)	0.50 (0.16-1.56)
			Year of diagnosis (years)	1.47 (0.75-2.91)	1.08 (0.97-1.19)
II		High % median income<$30,000		1.04 (0.68-1.59)	0.82 (0.24-2.78)
			High School education	3.28 (0.24-45.68)	1.88 (0.27-13.26)
			College education	3.15 (0.23-43-81)	1.82 (025-13.03)
			Post-graduate education	3.39 (0.25-46.95)	0.42 (0.03-6.31)
			PSA (ng/ml)	1.07 (1.03-1.11)	**1.16 (1.07-1.25)**
			Family History of Prostate Cancer	1.29 (0.84-1.99)	0.85 (0.32-2.24)
			Married	1.57 (0.79-3.09)	0.48 (0.16-1.41)
			Year of diagnosis (years)	1.00 (0.95-1.04)	1.08 (0.97-1.19)
III		Low % HS education		0.76 (0.49-1.18)	1.52 (0.42-5.57)

			High School education	3.34 (0.20-56.25)	1.87 (0.27-12.86)
			College education	2.96 (0.18-49.76)	2.09 (0.09-14.81)
			Post-graduate education	3.11 (0.19-52.21)	0.45 (0.03-6.75)
			PSA (ng/ml)	**1.07 (1.03-1.11)**	**1.15 (1.07-1.24)**
			Family History of Prostate Cancer	1.25 (0.82-1.91)	0.84 (0.32-2.20)
			Married	1.50 (0.76-2.94)	0.53 (0.18-1.60)
			Year of diagnosis (years)	1.00 (0.95-1.04)	1.07 (0.97-1.19)
IV		High % Female Head of Household		0.66 (0.43-1.02)	0.42 (0.12-1.48)
			High School education	3.38 (0.18-63.52)	1.68 (0.23-12.14)
			College education	2.89 (0.16-54.02)	1.39 (0.18-10.60)
			Post-graduate education	3.11 (0.17-57.91)	0.34 (0.02-5.69)
			PSA (ng/ml)	**1.07 (1.03-1.12)**	**1.16 (1.08-1.25)**
			Family History of Prostate Cancer	1.29 (0.85-1.97)	0.98 (0.35-2.71)
			Married	1.46 (0.75-2.84)	0.45 (0.15-1.33)
			Year of diagnosis (years)	0.99 (0.95-1.04)	1.08 (0.97-1.19)
V		High % No car		0.69 (0.45-1.06)	1.35 (0.35-5.19)

			High School education	3.25 (0.17-60.64)	1.92 (0.28-13.28)
			College education	2.94 (0.16-55-16)	2.12 (0.28-15.89)
			Post-graduate education	3.16 (0.17-59.21)	0.45 (0.03-6.76)
			PSA (ng/ml)	**1.07 (1.03-1.12)**	**1.15 (1.07-1.24)**
			Family History of Prostate Cancer	1.26 (0.83-1.91)	0.82 (0.32-2.16)
			Married	1.43 (0.72-2.82)	0.51 (0.17-1.52)
			Year of diagnosis (years)	1.00 (0.95-1.04)	1.07 (0.97-1.19)
VI		High % Public Assistance		0.99 (0.66-1.50)	0.52 (0.14-1.91)
			High School education	3.28 (0.23-46.81)	1.73 (0.24-12.56)
			College education	3.13 (0.22-44.73)	1.60 (0.21-11.93)
			Post-graduate education	3.36 (0.24-47.91)	0.36(0.02-5.91)
			PSA (ng/ml)	**1.07 (1.03-1.11)**	**1.16 (1.07-1.25)**
			Family History of Prostate Cancer	1.29 (0.85-1.97)	0.87 (0.33-2.27)
			Married	1.55 (0.79-3.03)	0.44 (0.14-1.34)
			Year of diagnosis (years)	1.00 (0.95-1.04)	1.08 (0.97-1.19)
VII		High % gun assaults/		0.69 (0.27-1.73)	**0.57 (0.08-3.93)

		High % graffiti		0.68 (0.21-2.15)	**1.63 (0.34-7.71)
		High % vandalism and criminal mischief		3.52 (0.81-15.23)	**1.77 (0.43-7.33)
			High School education	0.29 (0.05-1.56)	**1.17 (0.14-9.49)
			College education	0.32 (0.08-1.35)	**1.29 (0.18-9.43)
			Post-graduate education	0.33 (0.09-1.19)	**---
			PSA (ng/ml)	**1.10 (1.01-1.19)**	****1.11 (1.03-1.20)**
			Family History of Prostate Cancer	**3.81 (1.14-12.68)**	**2.08 (0.56-7.78)
			Married	1.75 (0.46-6.56)	**0.44 (0.11-1.78)
			Year of diagnosis (years)	0.99 (0.90-1.10)	**0.97 (0.85-1.11)
VIII		Deprivation Quartile 2		0.93 (0.58-1.50)	0.91 (0.17-5.01)
		Deprivation Quartile 3		0.86 (0.49-1.50)	0.31 (0.04-2.46)
		Deprivation Quartile 4		0.66 (0.19-2.35)	0.80 (0.18-3.65)
			High School education	3.37 (0.22-52.26)	2.27 (0.34-15.05)
			College education	3.12 (0.20-48.13)	1.81 (0.26-12.58)
			Post-graduate education	3.33 (0.22-51.11)	0.46 (0.02-8.94)
			PSA (ng/ml)	**1.07 (1.03-1.11)**	**1.18 (1.07-1.29)**

			Family History of Prostate Cancer	1.28 (0.84-1.96)	0.89 (0.33-2.39)
			Married	1.47 (0.74-2.89)	0.52 (0.17-1.56)
			Year of diagnosis (years)	0.99 (0.95-1.04)	1.07 (0.97-1.19)

*Deprivation quartiles were created from population-based deprivation calculations from Southeastern Pennsylvania (Zeigler-Johnson, et al. 2011)
**Logistic regression used because convergence of the model was not possible with GEE.
Note: To increase sample size for these analyses, multivitamin use and obesity were not included because of missing data.

Table 7. Demographics of SCORE Prostate Cancer Cases

Patient-Level Variables	Non-Obese (N=418)	Obese (N=107)	p-value
Median Age (years)	63	60	<0.001
% African American	11%	17%	0.104
% College Education	75%	60%	0.003
Median BMI	27	33.27	<0.001
% Ever Smokers	51%	60%	0.088
% family history prostate cancer	92%	91%	0.565
Median PSA at diagnosis (ng/ml)	6	5.3	0.077
% High Gleason (7-10)	44%	59%	0.005
% High Stage (III/IV)	26%	38%	0.010
Neighborhood-Level Variables			
Median neighborhood household income	$64,485.50	$56,797	0.005
Median percent high school education	91.4%	88.9%	0.004
Median percent college education	40.8%	32.7%	0.001
SES Discordance			
High Individual-High Neighborhood (Income)	48%	29%	0.002
Low Individual-High Neighborhood (Income)	27%	32%	
High Individual-Low Neighborhood (Income)	9%	11%	
Low Individual-Low Neighborhood (Income)	16%	29%	